

Serial No.: 10/642,916

REMARKS

Claim Rejections - 35 U.S.C. § 103

Claims 21-29 have been rejected under 35 U.S.C. § 103(a) over U.S. Patent No. 6,465,866 to Park. Claim 21 has been amended to more clearly recite that which the Applicants regard as the invention. In particular, claim 21 recites the affirmative act of "selecting an appropriate one of compressive stress or tensile stress that when exerted on the active region will enhance carrier mobility within the active region for the channel type of the semiconductor device" where the channel type is predetermined to be either p-channel (PMOS device) or n-channel (NMOS device). Claim 21 further recites that the liner exerts the selected stress type.

Park does not teach or reasonably suggest the act of selecting an appropriate stress that is exerted by a isolation trench liner to improve carrier mobility for a predetermined device type. The Examiner contends that Park teaches "exerting a compressive or tensile stress on the active region with the liner" and "that the compressive or tensile stress results in an enhanced carrier mobility in the active area (Col. 8, lines: 55-65- inverse narrow width effect is reduced)." However, contrary to these contentions, Park is not instructive or suggestive of the claimed subject matter. Rather, the trench isolation structure in Park is arranged to invoke a desired geometry in the Park's device (see, for example, column 2, line 36 to column, 3, line 21 setting forth the objects of Park's invention and how those objects are achieved).

There has been no showing that Park selects a particular type of stress to place on Park's active region based on the particular channel type of Park's device, especially for the purpose of improving carrier mobility. The assertion that Park teaches the exertion of compressive or tensile stress on the active region with the liner is incorrect as both compressive stress and tensile stress are exerted on the active region in Park. Therefore, Park fails to teach or reasonably suggest exerting a selected one of the stresses. Further, Park is an inoperative reference since Park does not teach or suggest a way to exert tensile stress on the active region with a trench isolation liner without also exerting compressive stress on the active region.

Serial No.: 10/642,916

A stated object of Park is to provide a particular trench isolation structure and gate dielectric film with increased thickness at the upper edges of the trench (see, for example, column 2, lines 36-40). Referring to the detailed description of Park at columns 7 and 8, Park explains how stresses play a roll in achieving the desired gate oxide film by contributing to an increase in oxidation at the top edges of the trench.

Park states that "a portion A of the semiconductor substrate 40 on the sidewall of a trench in contact with the silicon nitride liner 50 is subject to compressive stress" (column 7, lines 25-28). As shown in figure 7, the compressed area is directly adjacent the portion of the trench where the liner is formed. Above Park's region A where the liner is not present, "the portion B of the semiconductor substrate 40 near the surface of the active region is subject to tensile stress," which leads to more rapid oxidation of the substrate (column 7, lines 28-32). It is unclear whether the tensile stress is even generated by the liner or if the tensile stress results from thermal expansion of the substrate material that is not adjacent the liner.

The competing stresses and the lack of the liner adjacent region B allow more oxidation of the substrate at the upper corner of the trench and less oxidation adjacent the liner 50 so that the desired thicker portion of the gate oxide film can be formed (column 7, lines 33-52). During oxidation, the liner 50 acts as an oxidation barrier for region B.

The Examiner refers to the passage at column 7, lines 55-65 for the premise that Park teaches exerting compressive or tensile stress on the active region. This passage, however, refers to the growth of the gate oxide film. As the film grows, the film applies compressive force to the substrate that, in turn, slows the oxidation rate. As should be apparent, this stress is not tensile stress and is exerted by the growing gate oxide layer, rather than the liner. Thus, the compressive stress discussed in this passage is not exerted with the liner as claimed. Also, it is submitted that the compressive stress generated by the gate oxide material would counteract, or overcompensate for, any tensile stress previously present with respect to region B.

Serial No.: 10/642,916

At best, Park shows exerting compressive stress with a liner on a portion of a substrate and allowing tensile stress to develop in an area of the substrate not adjacent the liner. Both stresses are present to assist in invoking the desired gate oxide geometry.

In addition, Park makes no distinction between stresses applied to a p-channel device or an n-channel device.

As will be appreciated, there is no teaching or reasonable suggestion in Park to select one of tensile stress or compressive stress for exertion on an active region as claimed, especially for the purpose of enhancing carrier mobility (emphasis added). Rather, both stresses are present in Park to attain Park's stated objects of his invention. Since both stresses are present, it is submitted that there would be at least some, if not total, counteraction of any carrier mobility enhancement gained by the preferred one of the stresses for the device type in question. Also, once the gate oxide is grown, the compressive force of the gate oxide would diminish, if not overwhelm, the tensile stress present in region B before oxidation.

In addition, it will be appreciated that Park does not teach or reasonably suggest how to use a liner to exert tensile stress while not exerting compressive stress, or exerting only suitably minimal compressive stress, when tensile stress is the selected stress type for the device type.

With reference to the later statement of the Examiner regarding the relationship of inverse narrow width effect (INWE) and carrier mobility, Park explains that INWE "represents a reduction in threshold voltage with a decrease in the channel width of a transistor" (column 1, line 66 to column 2, line 6 and shown graphically in figure 3). INWE is typically most pronounced when the trench isolation meets the active region so that the active region has a sharp corner (column 1, lines 57-65). Furthermore, INWE has been characterized as a parasitic effect (see, for example, U.S. Patent No. 6,740,944 at column 2, lines 31-39: "INWE is a parasitic phenomenon which lowers the effective threshold voltage as the length of the gate becomes smaller").

Serial No.: 10/642,916

While INWE has a relationship to threshold voltage of a semiconductor device, there has been no showing that a reduction in INWE is the same as, or would result in, an improvement in carrier mobility. Referring to column 8, lines 55-60, the Examiner makes the unsubstantiated comment that INWE "is inversely proportionate to the carrier mobility of the active layer." It is submitted that the passage at column 8, lines 55-60 has been misinterpreted. Park states that INWE is "due to concentration of an electric field at the top edges of a trench" (column 7, lines 58-61). Park's solution of geometrical reconfiguration of the isolation region and gate oxide may lead to suppression of this electric field and, hence, a reduction in INWE. But there is no showing that reducing INWE would be responsible for an improvement in carrier mobility.

In view of these deficiencies of Park, even if (for the sake of argument) Park did teach or reasonably suggest the claimed material properties of the liner, the claimed invention would not result. Unmotivated changes to the teaching of Park would be required to arrive at the claimed invention, especially since Park does make any reference to carrier mobility or make any suggestion that carrier mobility could be improved as a direct function of the stress exerted by Park's liner.

In addition to the act of selecting the appropriate stress for the predetermined device type to improve carrier mobility, claim 21 recites that the liner has a relative permittivity, or K, of about 10 or more. As stated in the specification (e.g., page 4, line 23 to page 5, line 3, among other locations), materials having a K value appreciably lower than 10 are considered to be standard-K materials. It is reasonable to assume that K values that are 10% lower than 10 (i.e., a K of 9 or less) are appreciably lower than the claimed "about 10 or more." Standard-K materials, as defined by the Applicants, include silicon oxide (e.g., SiO_2), silicon oxynitride and silicon nitride (K of about 6-9). The only disclosed material for Park's liner is silicon nitride, which does not fall within the claimed class of materials that have a relative permittivity of about 10 or higher.

Serial No.: 10/642,916

For at least these reasons, claim 21 and claims 22-29 depending therefrom are considered to patentably define over the cited references. Accordingly, reconsideration and withdrawal of the rejection of claims 21-29 under 35 U.S.C. § 103(a) is respectfully requested.

Claim 30 is rejected under 35 U.S.C. § 103(a) over Park in view of U.S. Patent No. 6,008,095 to Gardner.¹ Claim 30 depends from claim 21 and is considered to be allowable for at least the reasons identified above.

In addition, the liner 120 used by Gardner is not a high-K liner. The liner 120 is formed by NO oxidation of the semiconductor substrate (see, column 4, lines 43-54), which would result in, for example, silicon oxynitride having a K value of about 4 to 8 depending on the relative concentration of oxygen and nitrogen.

It is acknowledged that the gate dielectric layer 104 in Gardner can be a high-K material, but there is no suggestion to make the liner 120 from a high-K material. The passage cited by the Examiner (column 4, lines 60-65) refers only to the use of the NO oxidized liner 120 together with the high-K gate dielectric 104 and cannot be reasonably interpreted as forming both the liner and gate dielectric from high-K material.

Accordingly, reconsideration and withdrawal of the rejection of claim 30 under 35 U.S.C. § 103 is respectfully requested.

Conclusion

In light of the foregoing, it is respectfully submitted that the present application is in condition for allowance and notice to that effect is hereby requested. If it is determined that the application is not in condition for allowance, the Examiner is invited to initiate a telephone interview with the undersigned representative to expedite prosecution of the present application.

¹ The Office Action does not identify the Gardner reference by patent number, but in a telephone message left by the Examiner for the undersigned representative on November 24, 2004 in connection with an earlier action for this application, it was communicated that the '095 patent was the intended reference.

Serial No.: 10/642,916

If there are any additional fees resulting from this communication, please charge same to our Deposit Account No. 18-0988, our Order No. G0603.

Respectfully submitted,

RENNER, OTTO, BOISSELLE & SKLAR, LLP

By 
M. David Galin; Reg. No. 41,767

1621 Euclid Avenue
Nineteenth Floor
Cleveland, Ohio 44115
Telephone: (216) 621-1113
Facsimile: (216) 621-6165

R:\DGalini\AMDS\PG0603usb\AMDSPG0603USB.R02.wpd